To DR. Cain's

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Sales Receipt

Product Description	Sale Qty	Unit Price	Final Price
SAN FRANCISCO CA 94131 Zone-8 First-Class Large Env 2.10 oz.			$1.30
Issue PVI:			$1.30
Total:			$1.30

Paid by:
AMEX $1.30
Account #: XXXXXXXXXXXX1003
Approval #: 515513
Transaction #: 951
23 903230258 4324705532

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FILE

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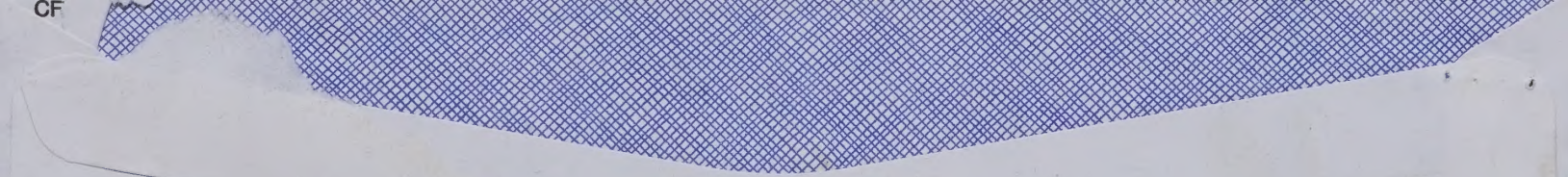
CF

FE27

Big Henry

SERVICE MANUAL

SENCORE

"the all american line"

SAFETY REMINDERS

When testing electronic equipment, there is always a danger present. Unexpected high voltages can be present at unusual locations in defective equipment. The technician should become familiar with the device that he is working on and observe the following precautions.

1. When making test lead connections to high voltage points, remove the power. If this cannot be done, be sure to avoid contact with other equipment or metal objects. Place one hand in your pocket as a safety precaution and stand on an insulated floor to reduce the possibility of shock.

2. Discharge filter capacitors before connecting test leads to them. Capacitors can store a charge that could be dangerous to the technician.

3. Be sure your equipment is in good order. Broken or frayed test leads can be extremely dangerous and can expose the technician to dangerous potentials.

4. Remove the test leads immediately after the test has been completed to reduce the possibility of shock.

5. Do not work alone when working on hazardous circuits. Always have another person close by in case of accident. Remember, even a minor shock can be the cause of a more serious accident, such as falling against the equipment, or coming in contact with high voltages.

SERVICE AND WARRANTY

You have just purchased the finest field effect multimeter on the market today. The Sencore FE27 had been inspected and tested twice at the factory and has passed a rugged use test by our Quality Assurance Department to insure the best quality instrument to you. If something should happen, the FE27 is covered by a standard 90 day warranty as explained on the warranty policy enclosed with your instrument.

Sencore has six regional offices to serve you. Instruments to be serviced should be returned to the nearest regional office by UPS if possible. Parcel post should only be used as a last resort. Instruments should be packed with the original packing materials or equivalent, and double boxed to insure safe arrival at the regional office. The display carton IS NOT an acceptable shipping container. When returning an instrument for service, be sure to state the nature of the problem to insure faster service.

If you wish to repair your own FE27 Field Effect Multimeter, we have included a schematic, trouble charts, and parts list. Any of these parts may be ordered directly from the regional office nearest you.

We reserve the right to examine defective components before an in warranty replacement is issued.

SENCORE REGIONAL OFFICES:

East Central Sales & Service
4105 Duke Street
Alexandria, Va. 22304
703 751-3556

Central Sales & Service
2711 B Curtis Street
Downers Grove, Illinois 60515
312 852-6800

Western Coast Sales & Service
833 Mahler Road
Burlingame, California 94010
415 697-5854

Central West Sales & Service
3200 Sencore Drive
Sioux Falls, South Dakota 57107
605 339-0100

Southeastern Sales & Service
2459 Roosevelt Hway Suite B-9
College Park, Ga. 30337
404 768-0606

Northeastern Sales & Service
1593 H Central Avenue
Albany, New York 12205
518 869-0996

3. Adjust R111 the BIAS ADJ control for plus 5 volts at the collector of TR102 measured with respect to the negative battery terminal.

DC CURRENT CALIBRATION

1. Select the +DCC function and the 1mA range. Connect a 1.5 volt battery, a know accurate DC milliameter, the FE27, a 500 ohm resistor and a 1,000 ohm variable resistor in series.
2. Adjust the variable resistor until the known accurate DC milliameter reads 1mA.
3. Adjust R113 the FE27 DCC CAL control until the FE27 indicates exactly 1mA full scale.

DC VOLTAGE CALIBRATION

1. Select the +DCV function and the 1V range, and connect the FE27 in parallel with a known accurate DC voltmeter set to measure 1 volt DC to the center tap of a 1,000 ohm potentiometer connected across a 1.5 volt battery.
2. Adjust the potentiometer for 1.0 volts DC as measured on the known accurage DC voltmeter.
3. Adjust R109, the FE27 DCV CAL control so that the FE27 indicates exactly 1 volt full scale.

AC RMS VOLTAGE CALIBRATION

1. Select the ACV RMS function and the 1V range. Connect the FE27 in parallel with a known accurate RMS or average reading AC voltmeter to the center arm of a 1000 ohm potentiometer. Connect the potentiometer to the 6.3 volt winding of a filament transformer.
2. Adjust the potentiometer until the known accurate AC voltmeter indicates exactly 1 volt RMS.
3. Adjust R110, the FE27 ACV RMS CAL control, so that the FE27 indicates exactly 1 volt full scale.

AC P-P VOLTAGE CALIBRATION

1. Select the ACV P-P function and the 1V range. Connect the FE27 in parallel with a known accurate P-P reading AC voltmeter to the center arm of a 1000 ohm potentiometer. Connect the potentiometer across the 6.3 volt winding of a filament transformer.
2. Adjust the potentiometer until the known accurate AC voltmeter indicates exactly 1 volt P-P.
3. Adjust R123, the FE27 ACV P-P CAL control, so that the FE27 indicates exactly 1 volt full scale.

AC VOLTS

Ranges: 0 to 0.3, 1, 3, 10, 30, 100, 300, 1000 rms volts full scale.
0 to 0.3, 1, 3, 10, 30, 100, 300, 1000 p-p volts full scale.
Input Resistance: 2.4 megohms shunted by 82pf.
Accuracy: ±3% of full scale true rms for sine or square waves @ 60 Hz.
±3% of full scale p-p @ 60Hz.

Frequency Response: 1DB @ 15Hz - 20KHz
3DB @ 10Hz - 40KHz

OHMMETER

Ranges: 0 to 1000 (RX1), 0 to 10,000 (RX10), 0 to 1M (RX1K), 0 to 100M (RX100K), 0 to 1000M (RX1M), with 10 ohms center scale.
Accuracy: ±2 degrees of arc.
Applied voltage: 1.5 volts from C cell.

DC CURRENT

Ranges: 0 to 10mA, 0 to 100mA, 0 to 1 amp
Accuracy: ±3%
Internal voltage drop: 230mV

GENERAL
Meter: 4½", 100uA, 2%
Overload protection: Up to 1500 volts on any voltage range.
Multiplier resistors: ½% deposited carbon type.
Power supply: Two 9 volt transistor radio batteries. Eveready No. 222 or equiv.
Ohms battery: One C cell, Eveready No. 1035 or equiv.
Meter light battery: One C cell, Eveready No. 1035 or equiv.
Meter light bulb: No. 131, 1.4V
Semiconductor complement: 1 - 2N3957 dual N channel FET, 2-2N4248 PNP transistors, 4 - 1N456 Diodes,
2-1N4148 diodes, 6 - 1N34A diodes, 4-1 amp 400 volt PIV rectifier, 1-LM3900 quad op amp.

Weight: 4¼ lbs. (1.95kg)
Height: 10 1/8" (25.7 cm)
Width: 5 5¾" (14.6 cm)
Depth: 3½" (8.9cm)

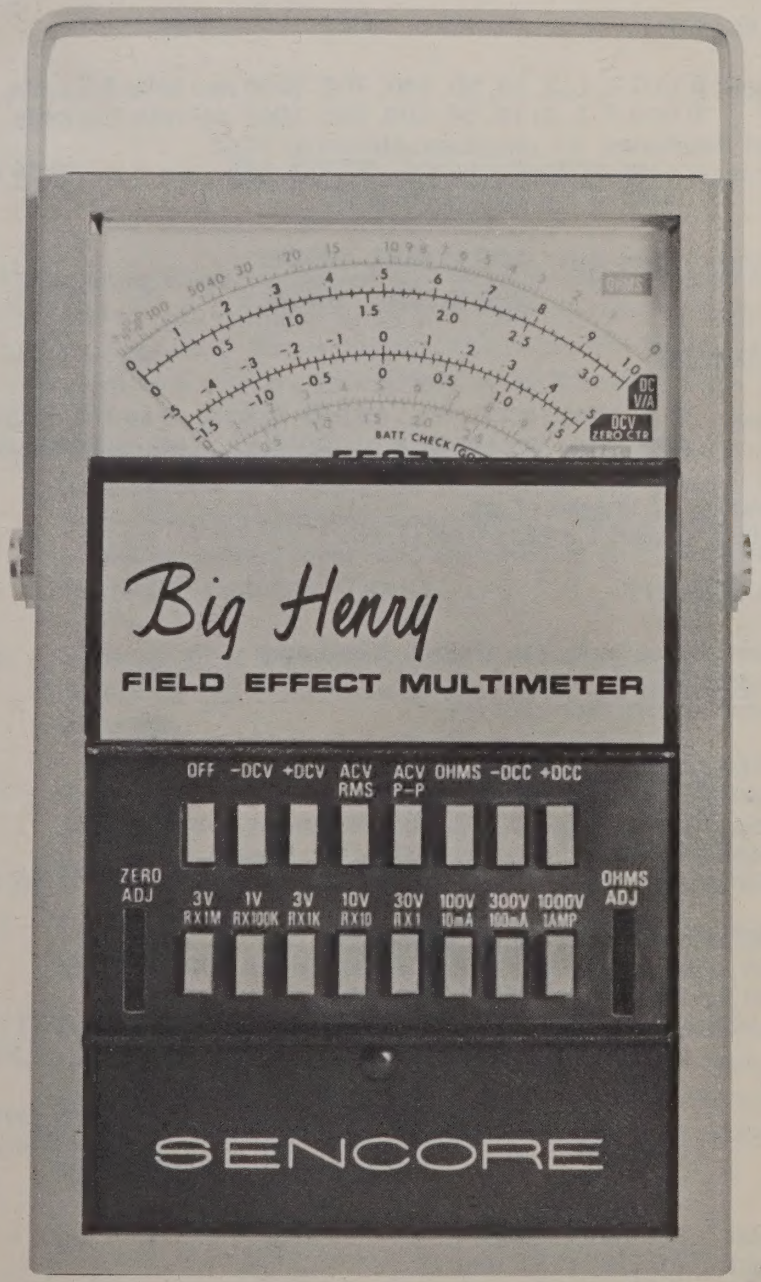

Fig.1 FE27 Big Henry

DISASSEMBLY INSTRUCTIONS

REMOVING THE CASE

1. Close the lead compartment door.
2. Remove the four chrome screws from the sides of the case.
3. Lift the case from the FE27.

REMOVING THE CHASSIS

(Case Removed)

1. Set the FE27 face down on a soft cloth.
2. Remove the six screws from the rear edges of the chassis.
3. Lift the chassis from the FE27.

REMOVING THE LEAD COMPARTMENT BRACKET

(Case and Chassis Removed)

1. Open the lead compartment door.
2. Remove the two screws from inside the lead compartment.
3. Lift the lead compartment bracket from the FE27, take care that the pushbutton switches and thumb wheel controls clear the holes in the front panel.

REMOVING THE SWITCH ASSEMBLY

(Case, Chassis, and Lead compartment removed)

1. Disconnect the five terminal molex connector from the main PC board to the right of the switch assembly.
2. Pull the switch assembly from the connector on the main PC board.

REMOVING THE METER

(Case and Chassis removed)

1. Unsolder the red and black meter wires from the PC board.
2. Remove the two 9 volt batteries from their holders.
3. Using a ¼ inch nut driver, remove the two nuts from the studs at the top of the meter, and the two short spacers that secure the bottom of the meter to the main PC board.

CALIBRATION INSTRUCTIONS

NOTE: Some calibration adjustments interact, and adjustments must be performed in the following order:

BIAS ADJUSTMENT (POWER SUPPLY BALANCE)

1. Select the +DCV function and the 1KV range. Adjust the front panel ZERO ADJUST control to the end of its rotation that produces a down scale indication on the meter.
2. Connect the negative terminal of a DC volt meter to the negative 9 volt battery lead, and the positive terminal to the collector of TR102.

DC CURRENT

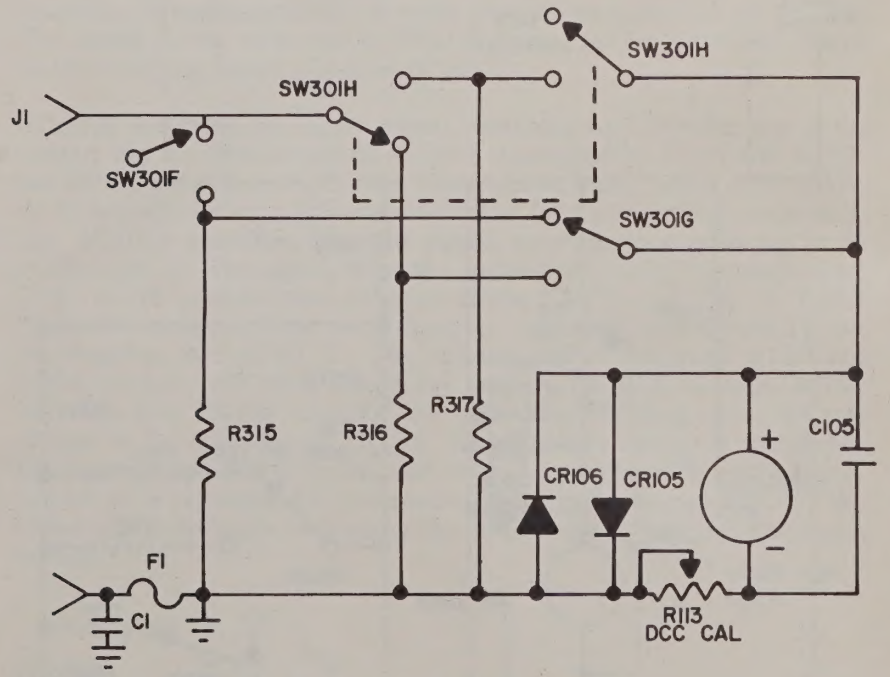

Fig. 18 DC current

The negative input connection of the plus DC current function is through the COMMON input jack, and the fuse F1 to the FE27 circuit ground. Also connected to the circuit ground are the current shunt resistors, and the negative terminal of the meter through R113 and DCC CAL control. R113 is a calibration adjustment adjusted for correct full scale reading. For the 100mA range, current flow through the FE27 is from the common input jack, through R316, the 100mA shunt, and the normally closed contacts of SW310F and SW310H to the positive input terminal. The positive meter terminal is connected directly to the 100mA shunt by SW310G.

The circuit for the negative DC current function is the same, except that the positive terminal of M1 is connected to FE27 circuit ground through R113, and the negative terminal is connected to the POS input jack.

CONTROLS

FUNCTION SWITCH: The eight gray pushbuttons in the top row are used to select the function for the type measurement being made. The first function button (OFF) removes power from the FE27. When any other function button is pressed the power is applied to the FE27 circuitry. The eight function pushbuttons are provided with a mechanical lockout so that only one function button may be depressed at one time.

RANGE SWITCH: The bottom row of eight red pushbuttons control the range switching for the FE27, and are provided with a mechanical lockout so that only one range button may be depressed at one time. Note that all eight function buttons apply to the AC and DC volts functions, while only the first five apply to the OHMS function, and only the last three apply to the DC current function. A safety factor has been built into the range switching so that if all the range buttons are out, the 1KV range is selected.

ZERO ADJUST: This thumb wheel control is used to position the meter pointer to zero on the extreme left edge of the meter scale. It should be adjusted with either the AC or DC volts function button depressed and the leads shorted together.

OHMS ADJUST: This thumbwheel control is used to compensate for lead resistance and changing battery voltage, and is adjusted in the ohms function with the leads shorted together. Adjust this control to position the meter pointer to the OHMS zero on the extreme right edge of the meter scale.

AUTOMATIC SHUT OFF: This specially designed leaf switch provides automatic turn off for the 9 volt meter amplifier batteries, the 1.5 volt "C" cell OHMS supply battery, and the 1.5 volt "C" cell scale illumination battery. Shut off occurs when the lead compartment door is closed.

BATTERY TEST: This spring return slide switch is used to test the condition of the 9 volt meter amplifier batteries. To test, select either the AC or DC volts function, and slide the BATT TEST switch to the right. Read the BATTERY GOOD scale on the meter.

SCALE ILLUMINATION: This slide switch must be ON, and a function other than OFF selected to apply power to the meter light. The scale illumination features should only be used when necessary, as the size of the battery for scale illumination limits its life to approximately 10 hours.

INPUT CONNECTIONS

COMMON: This black banana jack is the common input connection for all functions and ranges.
POS: This red banana jack is the positive input connection for all functions and ranges except the 3KV DC voltage range, and the 3 amp range.
3KV: This yellow banana jack is the positive input connection for the 3,000 volt DC voltage range.
3 AMP: This red banana jack is the positive input for the 3 amp range. The 3 amp jack can only be used with the special small diameter banana plug supplied.
NOTE: UNPLUG the 3 amp lead when not in use.

OPERATION

BATTERY INSTALLATION

Fig.2 Battery Installation

NOTE: The battery and fuse holder bracket is isolated from the case of the FE27. Do not remove the fish paper insulators surrounding the bracket, as a severe hot-chassis shock hazard could result.

1. Remove the two screws from the top rear of the case, and the battery/fuse compartment cover.
2. Insert the "C" cells (Eveready 1035 or equiv.) for the meter light and ohms supply. Observe proper polarity, and insert the button (positive) end of the "C" cell down toward the chassis of the FE27.
3. Connect two 9 volt batteries (Eveready 222 or equiv.) to the connectors, taking care not to damage the connectors.

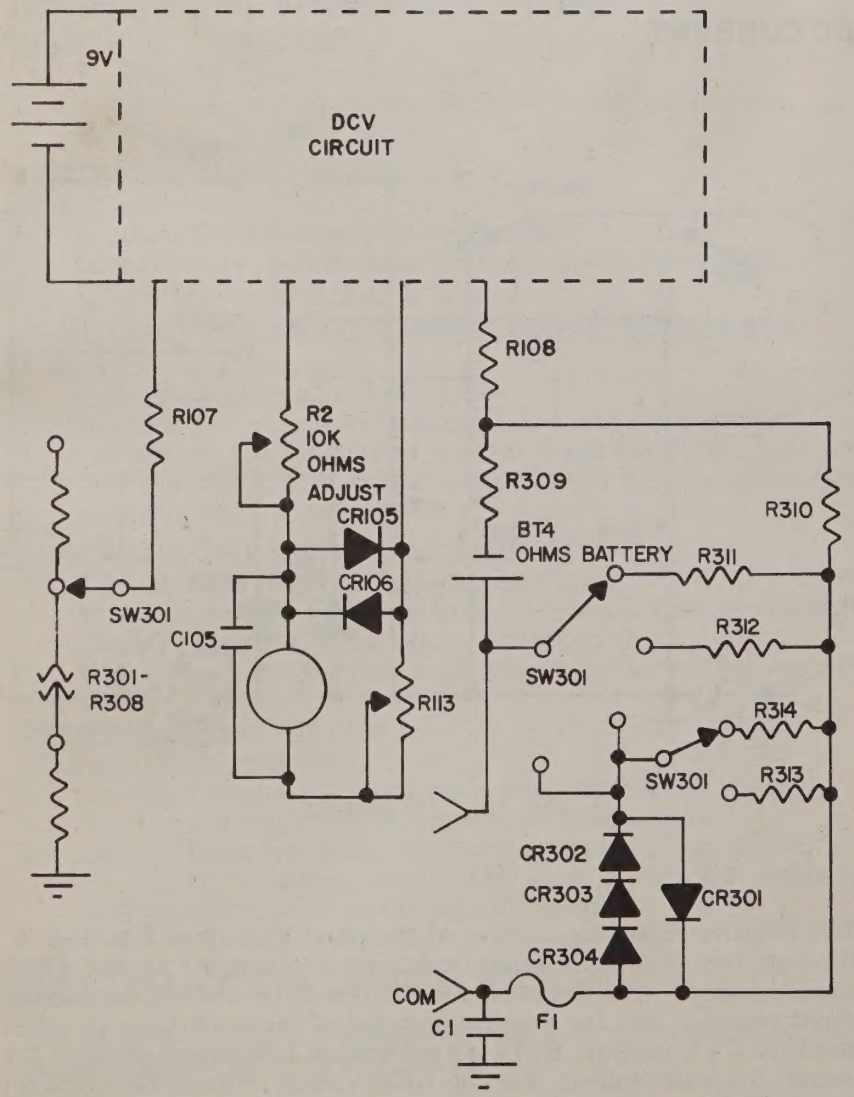

Fig. 17 Ohms measurement

For the RX100K, RX1K, RX10 and RX1 ranges the other standard resistors (R311 - R313) as selected by the range switch are connected in parallel with R309 and R310, resulting in ohms ranges whose center scale reading is equal to the parallel combination of the selected standard resistor and the 10 meg combination of R309 and R310.

TR101A. (NOTE: a 10 Meg ohm scope input connected to the gate of TR101A will load this voltage down to approximately .2 volts p-p). TR101A and TR102 amplify the signal at the gate of TR101A, resulting in approximately .6 volts p-p at the collector of TR102. The signal at the collector of TR102 is coupled by C106 and R110 to the inverting input, pin 6, of IC101A.

IC101A amplifies its input signal, resulting in 1.3 volts p-p at its output pin 5. The output of IC101A is coupled by C107 and R123, the ACV p-p CAL control to the noninverting input, pin 2, of IC101B. R123 is a calibration adjustment adjusted for a correct full scale reading. IC101B amplifies its input signal, resulting in 4 volts p-p at its output pin 4. The signal from the output of IC101B is coupled by C111 to the peak-to-peak detector diodes CR111 and CR112. C112 filters the output of the peak detector, resulting in -3.8 volts DC on the negative lead of C112. The voltage divider action of R129 and R130 couples -.22 volts DC to the gate of TR101B through R108. TR101B and TR103 amplify the -.22 volts, resulting in a -.44 volt change at the collector of TR103. This negative change is coupled to the negative side of the meter, and since the positive side of the meter is tied to a constant DC reference at the collector of TR102, the meter reads up scale, indicating the peak-to-peak value of the input voltage.

OHMS

The FE27 operates as a series ohmmeter, with the 1.5 volt supply battery, the internal standard resistor, and the unknown resistor connected in series. The gate of TR101B is used to measure the voltage across the internal standard resistor.

For the RX1M range, with the leads shorted, the entire ohms battery voltage appears across R309 and R310. R310 and R309 form a voltage divider that applies approximately -.3 volts to the gate of TR101B. TR101B and TR103 amplify this voltage, resulting in approximately a -.66 volt change at the collector of TR103. The -.66 volt change is coupled to the negative terminal of the meter, and since the positive meter terminal is tied to a constant DC reference at the collector of TR102, the meter indicates up scale. R1, the front panel ohms zero control, is adjusted for a full scale reading. If a 10 meg resistor is connected between the input leads, half the battery voltage will develop across the internal standard resistor, and the other half across the external 10 meg resistor. The voltage coupled to the gate of TR101B is then half of what it was with the leads shorted, and M1 indicated half scale, or a resistance of 10 meg ohms.

4. Install the 9 volt batteries with the connector up towards the underside of the meter movement.

GENERAL

Slide the meter cover down to expose the meter face. Pull down on the lip of the lead compartment door (away from the switch assembly) to unlatch the door, and slide the door into the case to gain access to the input leads and connections. Push one of the voltage or resistance functions to apply power to the FE27 circuitry, and test the condition of the 9 volt batteries with the BATT TEST switch. If the battery condition indicated is below the BATT CHECK GOOD area on the meter, replace the 9 volt batteries. Adjust the ZERO ADJUST control to position the meter pointer to zero on the left edge of the meter. This adjustment should not vary more than one small scale division on any function or range of the FE27. If it does, it is advisable to check the mechanical zero adjustment of the meter.

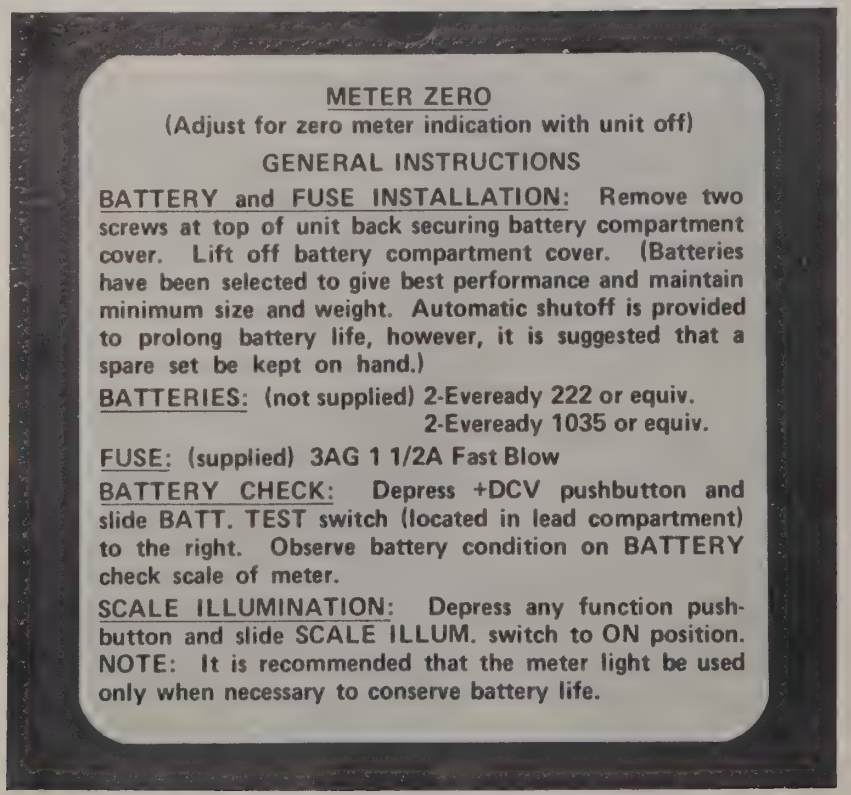
METER ZERO
(Adjust for zero meter indication with unit off)
GENERAL INSTRUCTIONS
BATTERY and FUSE INSTALLATION: Remove two screws at top of unit back securing battery compartment cover. Lift off battery compartment cover. (Batteries have been selected to give best performance and maintain minimum size and weight. Automatic shutoff is provided to prolong battery life, however, it is suggested that a spare set be kept on hand.)
BATTERIES: (not supplied) 2-Eveready 222 or equiv.
2-Eveready 1035 or equiv.
FUSE: (supplied) 3AG 1 1/2A Fast Blow
BATTERY CHECK: Depress +DCV pushbutton and slide BATT. TEST switch (located in lead compartment) to the right. Observe battery condition on BATTERY check scale of meter.
SCALE ILLUMINATION: Depress any function pushbutton and slide SCALE ILLUM. switch to ON position.
NOTE: It is recommended that the meter light be used only when necessary to conserve battery life.

Fig.3 Mechanical Zero Adjust

MEASURING DC VOLTAGE
1000 VOLTS OR LESS

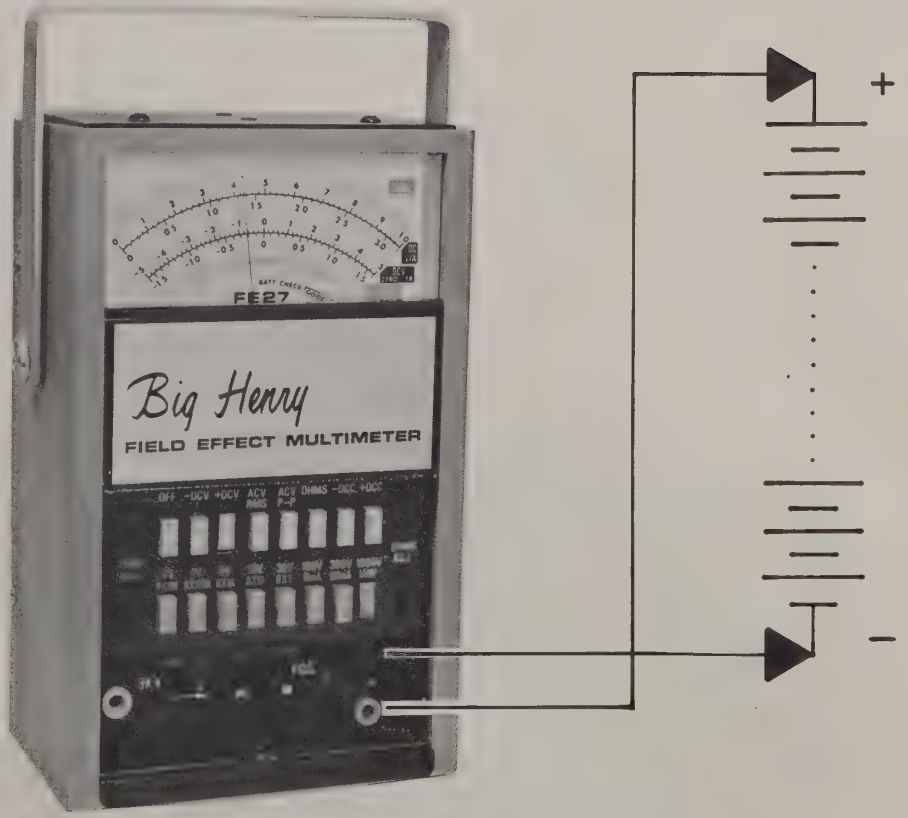

Fig.4 Measuring DC volts 0-1000V

Determine the polarity of the voltage to be measured with respect to the common or ground terminal of the equipment being measured. Select the +DCV function if the voltage is positive with respect to common, or the -DCV function if the voltage is negative. Determine what voltage you expect to measure, and select a range that will give a reading as close to full scale as possible. If the voltage to be measured is unknown, start with the 1KV range, and work toward the .3V range. Plug the banana plug end of the black input lead in to the equipment being measured. Plug the banana plug end of the red test lead into the POS input jack, and touch the probe end to the voltage point. Read the DC voltage on one of the black DC V/A scales directly above the mirror on the meter.

For the .3V range, read the 0 to 3.0 scale, and multiply the reading by .1. For the 3V range, read the 0 to 3.0 scale directly. For the 30 V,

The out of phase signals at the outputs of IC101C and IC101D are rectified by CR107 and CR109, producing a 2 volt peak pulsating DC signal at the junction of R126, CR107, and CR109. If a DC meter were connected at this point, it would respond to the average value of the original .3 volt RMS input signal.

The out of phase signals at the outputs of IC101C and IC101D are also rectified by CR108 and CR110, and filtered by C110, producing 2.1 volts DC at the junction of CR108, CR110, and R127. If a DC meter were connected at this point, it would respond to the peak value of the original .3 volt RMS input signal.

R126, R127 and R128 form a matrix that mixes approximately 80% of the average value, and 20% of the peak value, so that the DC voltage across R128 responds to the RMS value of a sine wave at the FE27 inputs. If the FE27 input signal is a square wave, the DC voltage across R128 still responds to the RMS value, because average, peak, and RMS are all equal for a square wave.

The negative DC voltage across R128 is coupled to the gate of TR101B by R108. C104 bypasses any stray pickup that may be present at the gate of TR101B. With .3 volts RMS applied to the .3V range, the voltage coupled to the gate of TR101B is approximately -.24 volts. TR101B and TR103 amplify this -.24 volts, resulting in a -.5 volt change at the collector of TR103. This negative change is coupled to the negative side of the meter, and since the positive side of the meter is tied to a constant DC reference at the collector of TR102, the meter reads up scale indicating the RMS value of the input voltage.

AC P-P VOLTAGE

NOTE: Because of the current input nature of the LM3900 Op Amp (IC101) it is not possible to make signal voltage measurements directly at its inputs.

The common input for the ACV P-P function is through the COMMON input jack, and the fuse F1 to the FE27 circuit ground. The hot input is coupled in through the POS input jack and C201 to the top of the range voltage divider. R201 is connected in parallel with the voltage divider to limit the input impedance on the AC voltage function, thereby reducing stray pickup on the input leads.

The Range switch and voltage divider provide the same function as in DC-volts. The output of the range switch is coupled to the gate of TR101A. .3 volts RMS (.8 volts p-p) applied to the inputs, and the 1V p-p range selected, results in .25 volts p-p coupled to the gate of

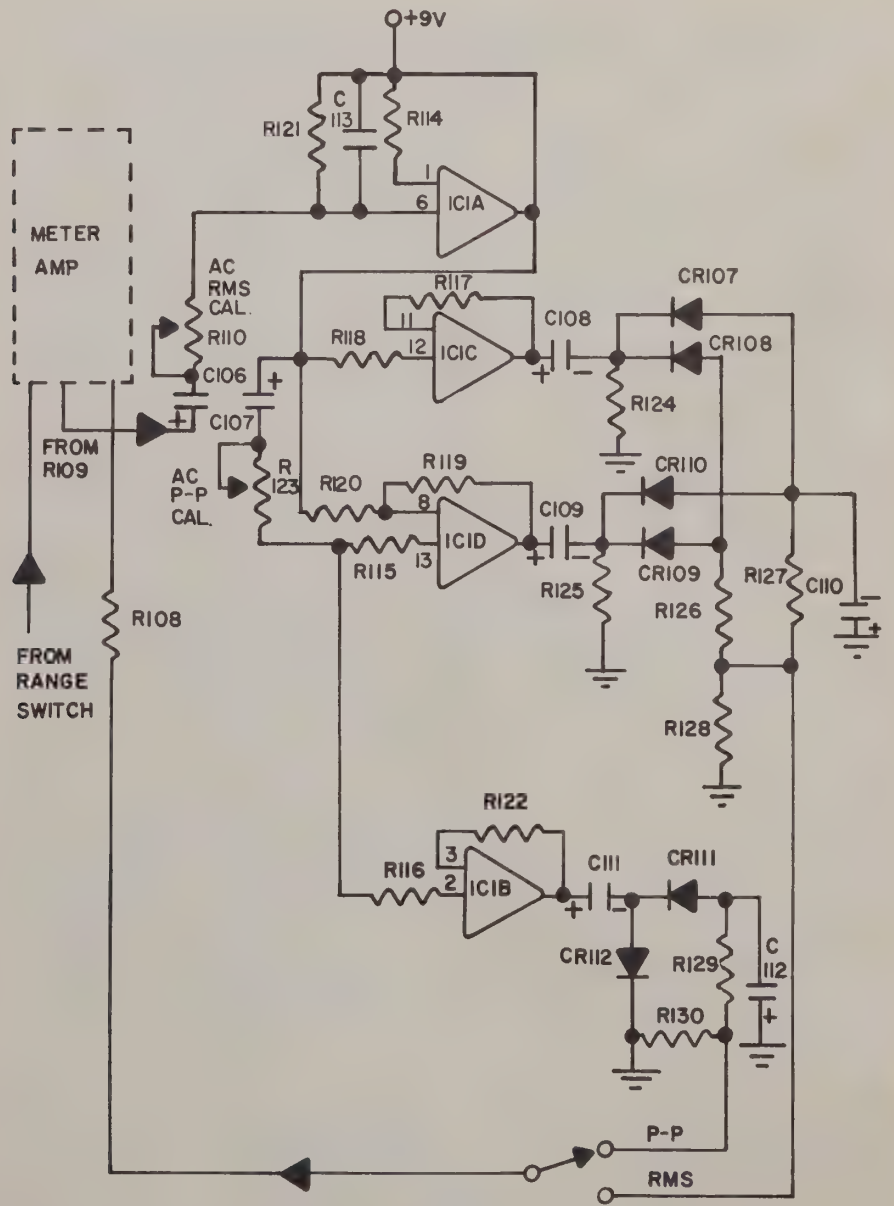

Fig. 16 AC voltage, RMS or P-P

amplifies its input signal, resulting in 4 volts p-p at output pin 5. The signal at the output of IC101A is coupled to the inverting input, pin 8, of IC101B, by R120, and to the noninverting input pin 12, of IC101C by R118.

and 300V ranges, read the 0-3.0 scale and multiply the reading by the appropriate multiplier. Each small scale division on the 0 to 3.0 scale is equal to .1. Example: If the meter indication were one small scale division above the 2.5 mark, the scale reading would be 2.6. If the 300V range were being used, the measured voltage would be 2.6 times 100, or 260V DC.

For the 1V range, read the 0 to 1.0 scale directly. For the 10V, 100V, and 1000 V ranges read the 0 to 1.0 scale, and multiply by the appropriate multiplier. Each small scale division on the 0 to 1.0 scale is equal to .02. Example: If the meter pointer indicated one small scale division above the .4 mark, the scale reading would be .42. If the 1KV range were being used, the measured voltage would be .42 times 1000, or 420 volts DC.

MEASURING DC VOLTAGE 1000-3000 VOLTS

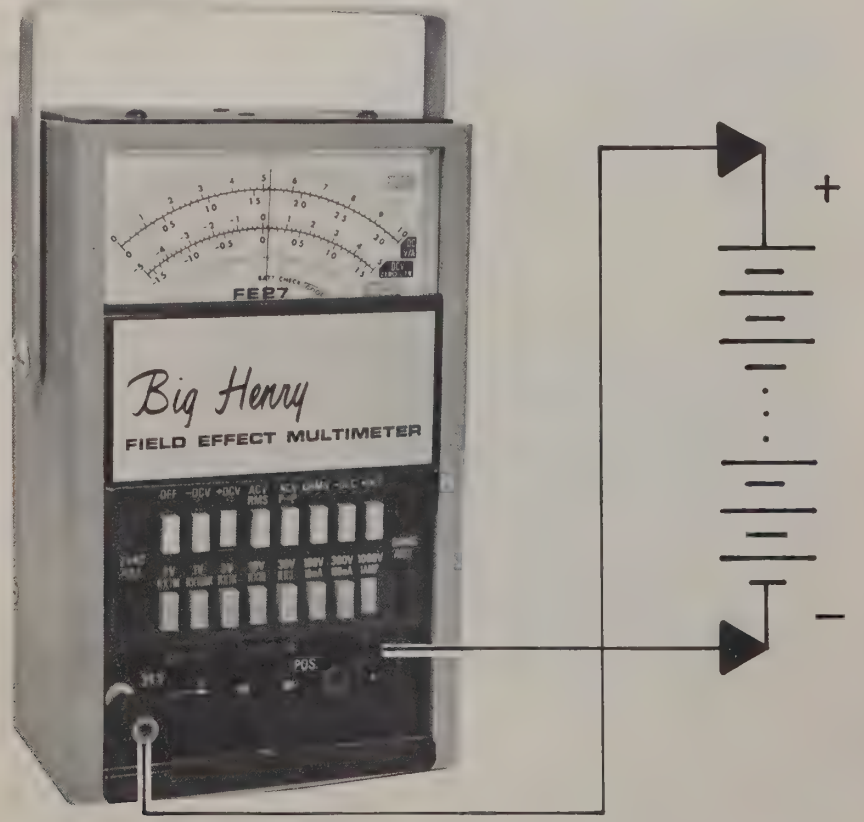

Fig.5 Measuring DC volts 1000-3000V

Determine the polarity of the voltage to be measured with respect to the common or ground terminal of the equipment being measured. Select the +DCV function if the voltage is positive with respect to common, or the -DCV function if the voltage is negative. Select the 1KV range. Plug the banana plug end of the black input lead into the COMMON input jack, and clip the alligator clip end to the common or ground point in the equipment measured. Plug the banana plug end of the red test lead into the voltage and multiply the reading by 1,000. Each small scale division would be equal to .1KV, or 100 volts. Example: If the scale indication were one small scale division above the 1.5 mark, the measured voltage would be 1.6KV, or 1600 volts.

MEASURING DC VOLTAGE WITH ZERO CENTER

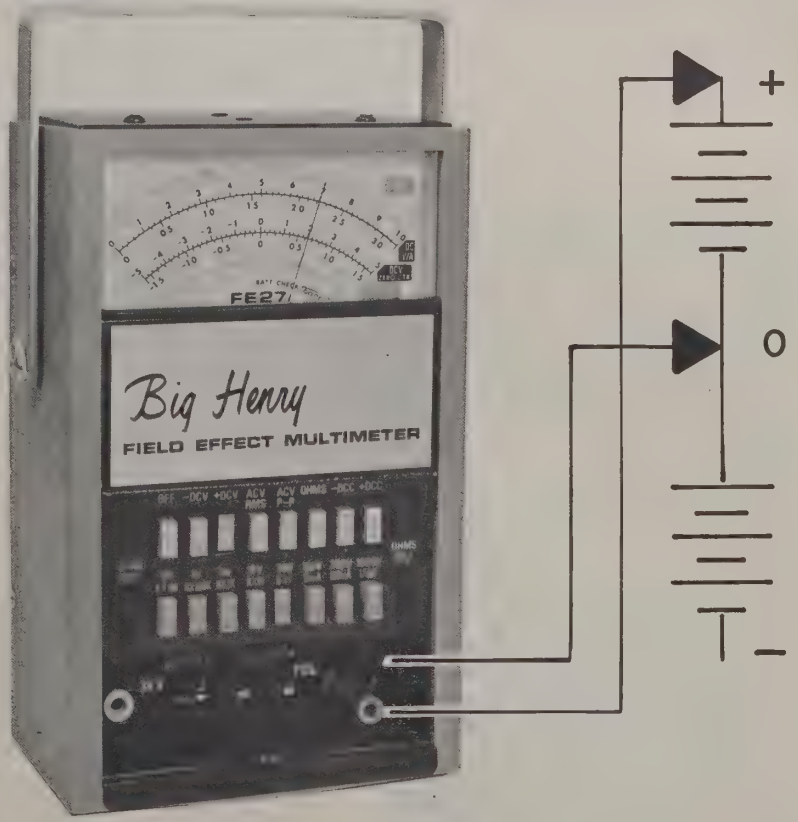

Fig.6 Measuring DC volts Zero Center

Select the +DCV function, and adjust the ZERO ADJUST control to position the meter pointer to the zero at the center of the DCV ZERO CTR scale. Determine what voltage you expect to measure, and select

tion resulting in an increase in the base current in TR102. The increase in TR102 base current decreases the emitter collector resistance of TR102, changing the collector voltage in the positive direction.

The positive change at the collector of TR102 adds to the positive .25 volt change at the junction of R103 and R101 (source of TR101A) resulting in a positive .65 volt change at the collector of TR102. The positive .65 volt change is coupled through the DCV CAL control R109 to the positive side of the meter. Since the negative side of the meter is tied to the collector of TR103 (which remains at constant voltage) through the DCC CAL control R113, the meter reads up scale indicating a positive voltage. R109 is a calibration adjustment adjusted for accurate meter indication of the applied DC voltage. (Note: R113 will also affect the calibration of DC volts, and should be adjusted before R109).

R1, the BIAS control, is a calibration adjustment adjusted for +5 volts measured between the collector of TR102 and the negative battery lead.

The -DCV function is basically the same as the +DCV function, except that the COMMON input is positive. The POS input is negative. The collector of TR102 is connected to the negative side of the meter through R109 and R113. The collector for TR103 is connected directly to the positive side of the meter.

AC RMS VOLTAGE

NOTE: Because of the current-input nature of the LM3900 op amp (IC101) it is not possible to make RMS signal voltage measurements directly at its inputs. The common input for the ACV RMS is through the COMMON input jack, and the fuse F1 to the FE27 circuit ground. The hot input is coupled in through the POS input jack and C201 to the top of the range voltage divider. R201 is connected in parallel with the voltage divider to limit the input impedance on the AC voltage function, thereby reducing stray pickup on the input leads.

The range switch and voltage divider provide the same function as in the DC voltage function. The output of the range switch is coupled to the gate of TR101A. If .3 volt AC RMS is applied to the inputs, and the .3V range selected, the voltage coupled at the gate of TR101A is .3V RMS, or .8V p-p. TR101A and TR102 amplify the input signal resulting in 1.8 V p-p at the collector of TR102. The signal at the collector of TR102 is coupled by C106 and R110 the AC RMS CAL control to pin 6, the inverting input, of IC101A. R110 is a calibration adjustment adjusted for a correct full scale reading. IC101A

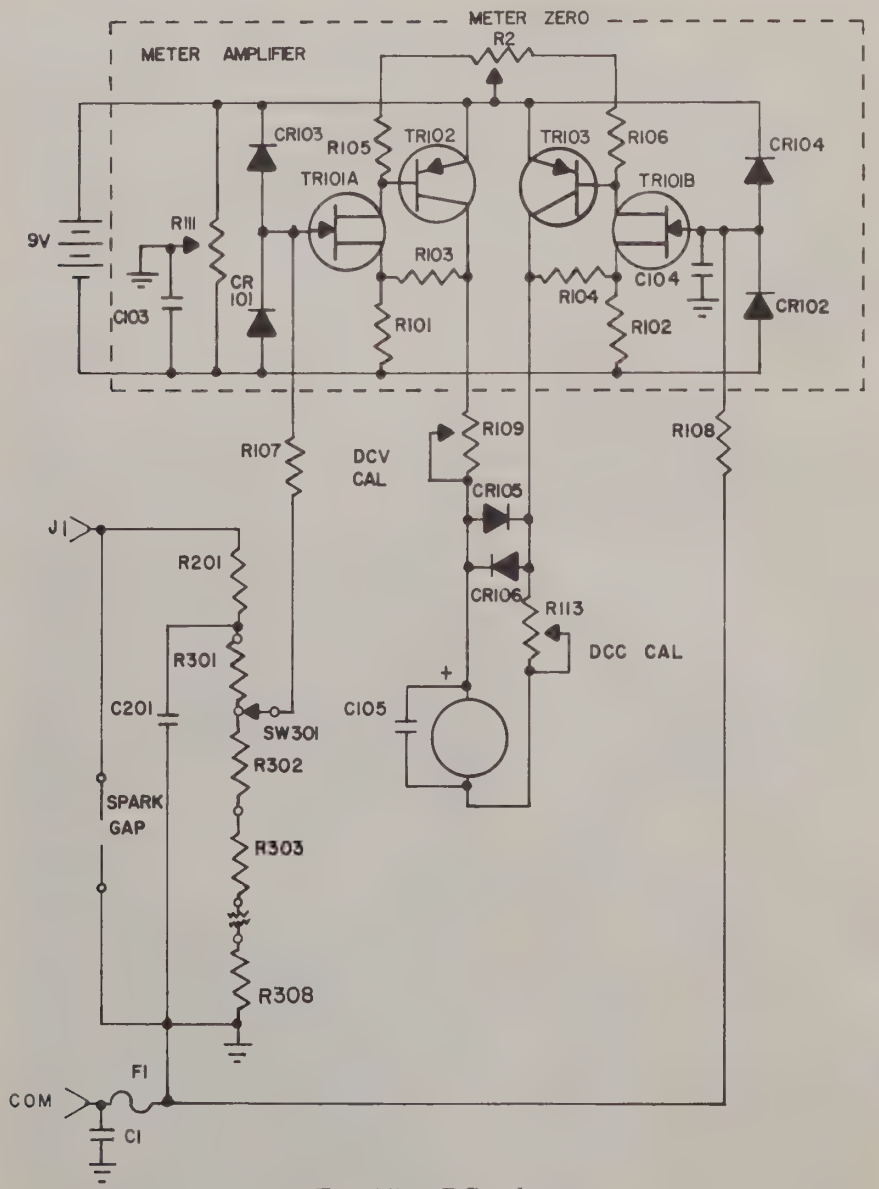

Fig. 15 DC voltage

If .3 volts is applied to the inputs, and the .3V range selected, the voltage coupled to the gate of TR101A is .25 volts. The .25V at the gate, results in a positive .25 volt change at the source of TR101A. The drain voltage of TR101A changes slightly in the negative direc-

a range pushbutton that will allow a reading as close to full scale as possible.

Note that the ranges for zero center are exactly one half of those listed on the front panel. For example, the 300V range provides a zero center range of -150V -0+150V. Plug the banana plug end of the red test lead into the POS input jack, and touch the probe tip to the voltage point. If the meter indicates to the right of the center zero, the measured voltage is positive, and if the meter indicates to the left of the center zero the measured voltage is negative. Read the DC voltage on the black ZERO CTR scales directly below the mirror.

For the .3V, 3V, 30V, and 300V ranges, read the -1.5 - 0 - 1.5 scale, and multiply by the appropriate multiplier. Each small scale division on the -1.5 - 0 - 1.5 scale is equal to .1. Example: If the meter indication were one small scale division above the .5 mark to the right of the center zero, the scale reading would be +.6 times 10, or +6 volts DC.

For the 1V, 10V, 100V, and 1KV ranges, read the -.5 - 0 - .5 scale, and multiply by the appropriate multiplier. Each small scale division on the -.5 - 0 -.5 scale is equal to .02. Example: If the meter indication were 3 small scale divisions below the -.2 mark to the left of the zero center, the scale reading would be -.26. If the 100V button were depressed, the measured voltage should be -.26 times 100, or -26 volts DC.

MEASURING AC VOLTAGE

Depress the RMS ACV pushbutton if a measurement of the RMS value is desired, or the P-P ACV pushbutton if a measurement of the peak to peak value is desired. Select a range that will produce a reading as close to full scale as possible. If the voltage being measured is unknown, start with the 1KV range, and work toward the .3V range. Plug the banana plug end of the black test lead into the COMMON input jack, and connect the alligator clip end to the common or ground point in the equipment being measured. Plug the banana plug end of the red test lead into the POS input jack, touch the probe tip to the voltage point, and read the voltage on the red ACV scales directly above the BATT CHECK GOOD scale.

For the 1V, 10V, 100V, and 1KV ranges, use the 0 to 1.0 scale, and multiply the scale reading by the appropriate multiplier. Each small division on the 0 to 1.0 scale is equal to .02. Example: If the meter indication were 2 small scale divisions above the .6 mark, the scale indication would be .64. If the 10V range were being used, and the RMS ACV pushbutton depressed, the measured voltage would be .64 times 10V, or 6.4 volts AC RMS.

For the .3V, 3V, 30V, and 300V ranges use the 0 to 3.0 scale, and multiply by the appropriate multiplier. Each small scale division on the 0 to 3.0 scale is equal to .1. Example: If the meter indication were 3 small scale divisions above the 2.5 mark, the scale indication would be 2.8. If the 3V scale were being used, and the P-P ACV push-button depressed, the measured voltage would be 2.8 volts AC P-P.

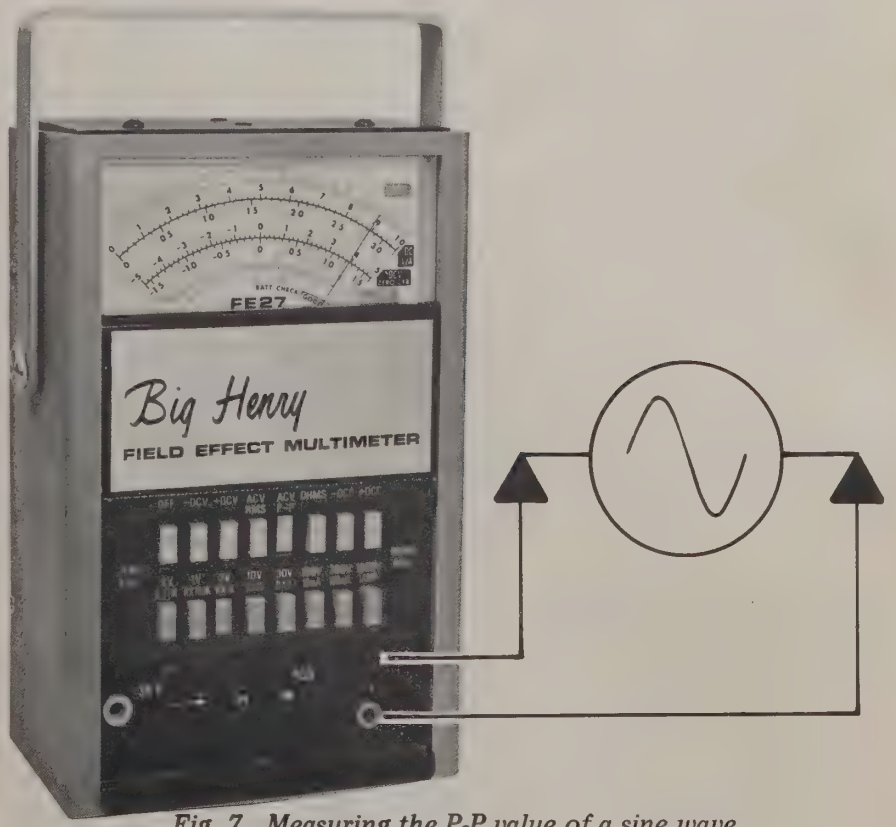

Fig. 7 Measuring the P-P value of a sine wave

The relationship between the P-P value and the RMS value of the measured voltage will depend on the waveshape of the measured voltage. Theroetically, if the measured voltage is a sine wave, the P-P value will be 2.8 times the RMS value. If the measured voltage is a square wave, the P-P value will be 2 times the RMS value. The practical measured difference between the P-P and RMS values for a given voltage will depend on the purity of the waveshape of the voltage. A sine wave with cross over distortion will measure a higher P-P value than 2.8 times the RMS value. A sine wave with clipping distortion will measure a lower P-P value than 2.8 times the RMS value. A square

OVERLOAD PROTECTION

Your FE27 is protected against accidental overloads on all ranges and functions. The voltage ranges are protected by the high input impedance. This limits the amount of current that can flow into the meter to safe levels. On the resistance and current functions, the fuse F1 protects both the meter movement and the circuitry. This fuse should be replaced with one of the same type so the protection feature and accuracy of the FE27 are not affected. The meter and internal resistors are further protected by the action of diodes CR105, 106, 301, 302, 303, 304.

FUSE REPLACEMENT

A quick check for the fuse is to short the leads on ohms. If the meter moves to the right, the fuse is good. If not, remove the battery cover and check the fuse. When the fuse is bad, it should be replaced with a 3 AG 1.5 amp fuse. Do not use a slow blow type fuse as inaccuracy and possible damage to the meter may result.

SCALE ILLUMINATION BULB REPLACEMENT

Follow the disassembly instructions for removing the meter, but do not unsolder the meter leads. Unscrew the scale illumination bulb from its holder, and replace it with a number 131 pilot lamp. Do not substitute any other lamp, as decreased life of the scale illumination battery, and/or decreased light output will result.

CIRCUIT DESCRIPTION

DC VOLTAGE

The negative input for the +DCV function is through the common input jack, and fuse F1 to the FE27 circuit ground. The positive input is through either the POS input jack, or the 3KV jack and R132. The positive input is then connected through R201 to the range voltage divider (R302 - R308). C201 in conjunction with R201 form a low pass filter to reject any AC component of the input voltage. Capacitors C301 - C308 are in the circuit for frequency compensation on AC voltage measurements, and have no effect on circuit operation in DC volts. The range switch SW301, selects the point on the voltage divider to be connected to the input of TR101A. For the .3V range, the voltage across the entire divider is selected, and for the 1KV range the voltage across the lowest resistor in the divider string (R308) is selected.

parts are firmly seated together. Insert the red FE27 test probe into the small hole in the high-voltage probe handle. Be sure that the tip of the test probe and the tip jack inside the handle of the 39A30 are properly aligned, and push the test probe firmly into the handle of the 39A30 to insure a good connection. Remove power to the equipment being measured, and connect the black lead to an appropriate ground point in the equipment being measured. Use the hook on the end of the 39A30 to connect the probe to the high-voltage test point, and apply power to the equipment being measured. Read the 0 to 3.0 scale and multiply the scale reading by 10,000. Each small scale division on the 0 to 3.0 scale is equal to 1,000 volts. Example: If the scale reading were two and one half divisions above the 2.0 mark on the meter, the measured voltage would be 22.5KV.

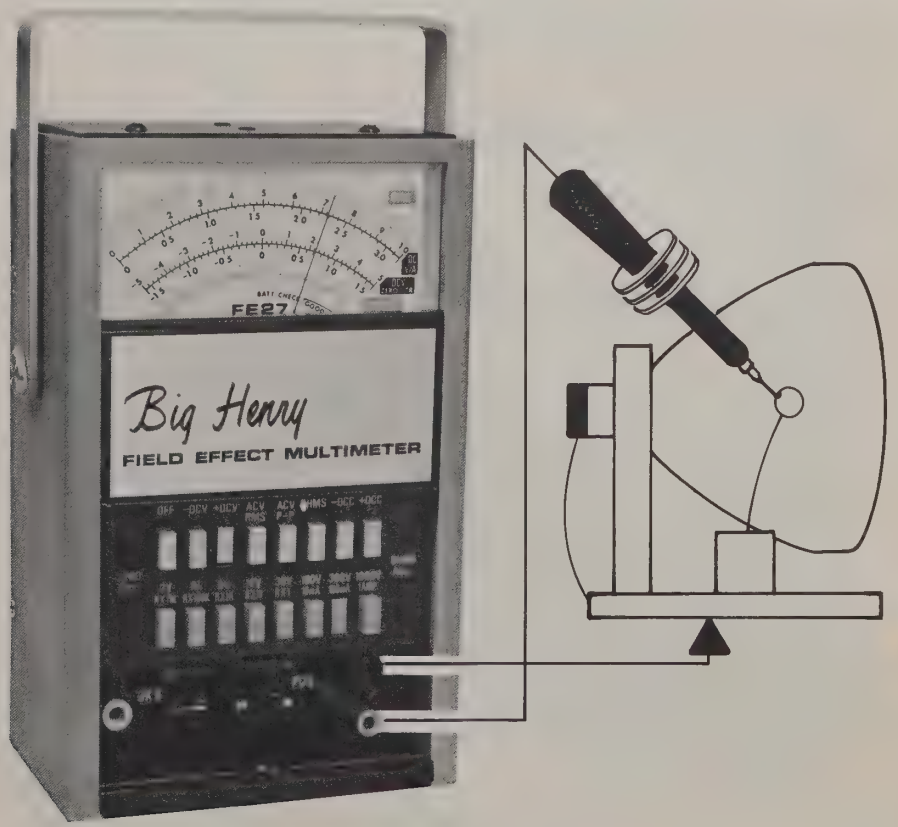

Fig.14 Measuring high voltage with the 39A30 probe (optional)

wave with a slow rise and fall time will measure a higher P-P value than 2 times the RMS value. NOTE: The examples in figures 7 and 8 are the theroetic values for perfect sine waves.

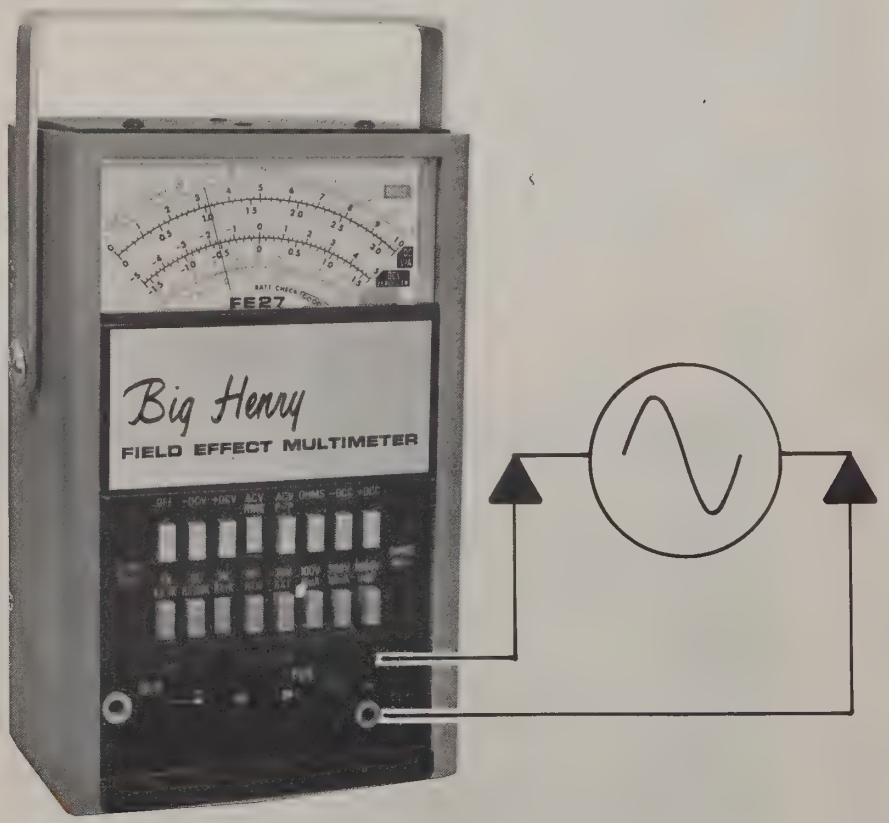

Fig. 8 Measuring the RMS value of a sine wave

MEASURING RESISTANCE

NOTE: Be sure to remove power from the circuit being tested. If voltage is applied to the inputs in either RX1 or RX10 ranges, the fuse F1 will open, making the FE27 inoperative until the fuse is replaced.

Be sure to discharge all filter capacitors when making in-circuit resistance measurements. In circuits containing transistors, lift one end of the resistor out of circuit before making resistance measurements.

Depress the OHMS function pushbutton, and a range pushbutton that will allow a reading as close to midscale as possible. Plug the black test lead into the COMMON input jack, and the red test lead into the POS input jack. Short the leads together, and adjust the OHMS ADJUST control to position the meter pointer to the ohms zero at the right edge of the meter scale. Unshort the leads, and connect them to the resistance being measured.

Read the top scale of the meter directly for the RX1 range or multiply by the appropriate multiplier for the RX10, RX1K, RX100K or RX1M range. Example: If the scale reading were 1.8, and the range RX1M, the measured resistance would be **1.8 meg,** or 1,800,000 ohms.

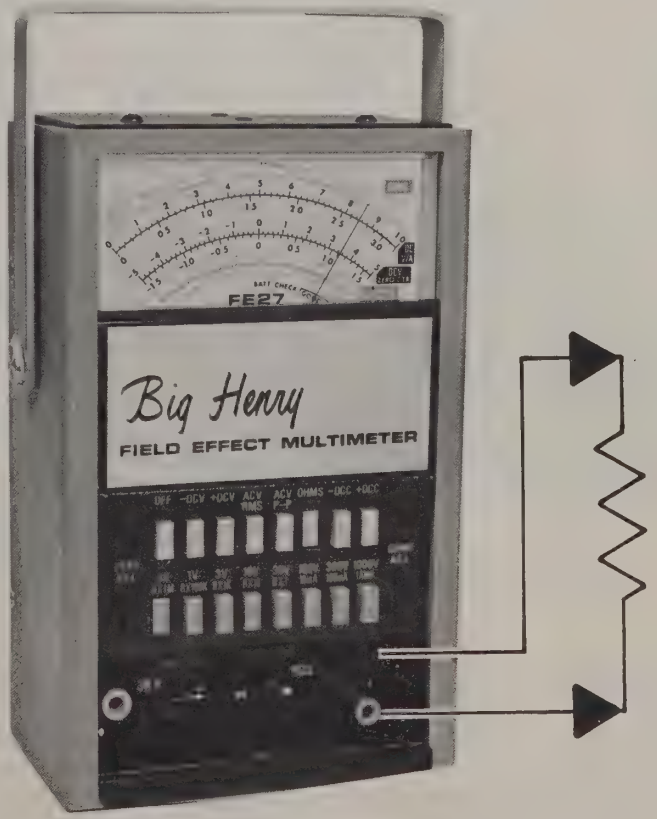

Fig.9 Measuring resistance

FE27 and shunt in series with the circuit being measured, with the black lead clipped to the common or ground point, as shown in Figure 12. Turn the power back on and read the current on the 0 to 3 DC V/A scale directly as 0 to 3 amps.

MEASURING AC CURRENTS WITH THE 39G82 SHUNT (OPTIONAL)

The 39G82 shunt can also be used to measure AC currents. Simply insert the shunt into the COMMON and POS jacks and connect the test leads as described in the preceding section.

Select the rms AC function and the .3V range and connect the meter and shunt combination in series with the AC line as shown in Figure 13. Read the AC current on the 0 to 3ACV scale directly as 0 to 3 amps.

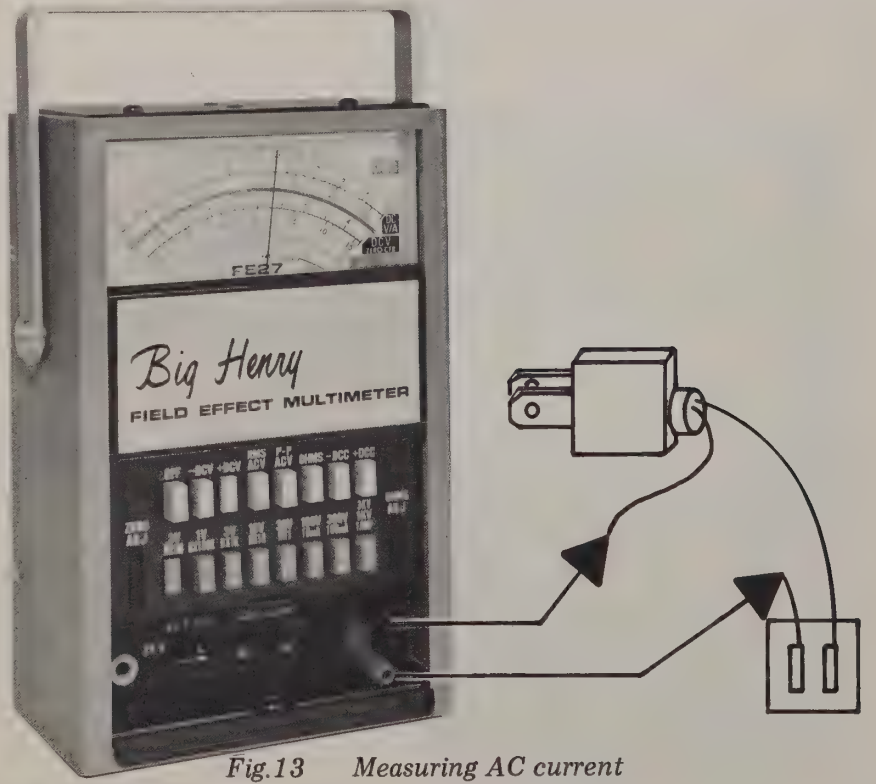

Fig.13 Measuring AC current

MEASURING HIGH VOLTAGE WITH THE 39A30 PROBE (OPTIONAL)

Depress the DCV and 300V pushbuttons, plug the black test lead into the COMMON input jack and the red test lead into the POS input jack. Assemble the 39A30 high-voltage probe, making sure the two

terminals of a double ¾ inch banana plug. The voltage developed across the shunt by the current is measured on the .3V range.

Determine the polarity of the current to be measured with respect to the common or ground point in the equipment being measured. If the voltage producing the current is positive with respect to common, select the +DCV function or if the voltage producing the current is negative with respect to common, select the -DCV function. Select the .3V range for measurements to 3 amps.

Insert the banana plugs of the 39G82 shunt into the COMMON and POS input jacks. Then insert the black test lead into the shunt jack connected to the COMMON input and the red lead into the shunt jack connected to the POS input.

Turn the power off to the equipment being measured, and open the circuit being measured at the common or ground point. Connect the

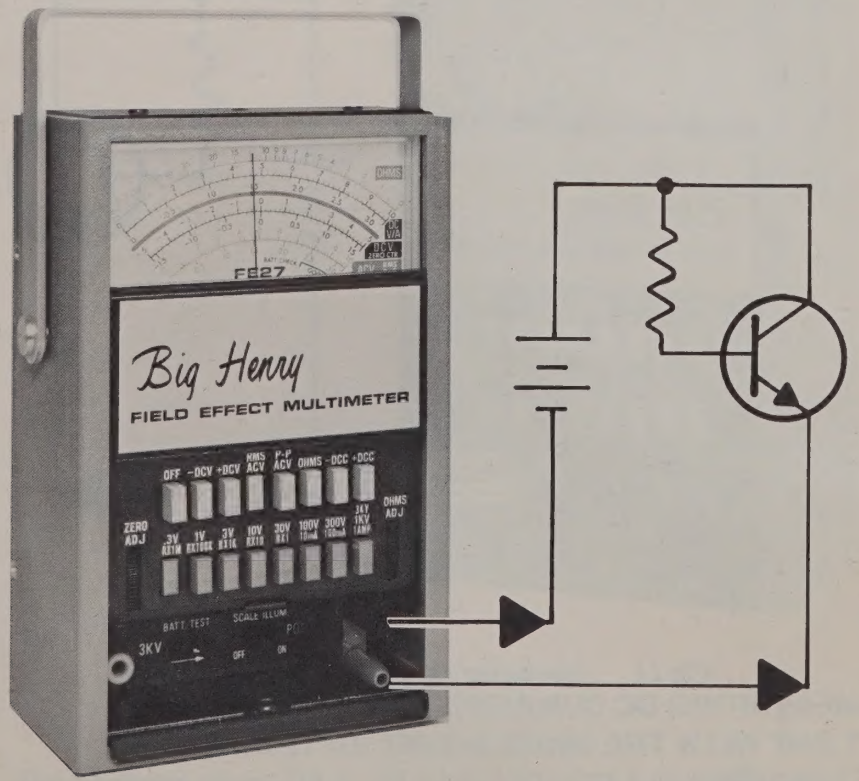

Fig.12 Measuring DC current to 3 amps

CHECKING DIODES

The front to back ratio of transistors and diodes may also be tested with the FE27 using the RX1K ohms range. With the black (negative) lead connected to the cathode of the diode, the resistance reading should be low. The resistance reading should be high with the red (positive) lead connected to the cathode of the diode. The ratio between the high and low readings should be at least 100:1 for a small germanium diode, and 1,000:1 for a silicon diode.

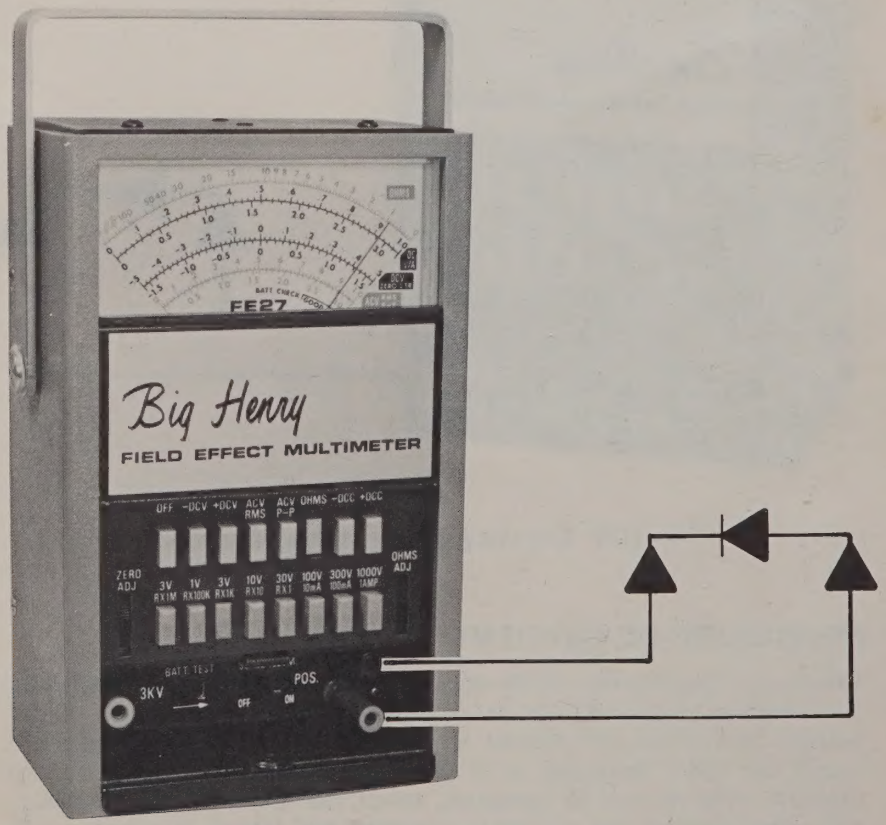

Fig. 10A Checking diodes, forward direction

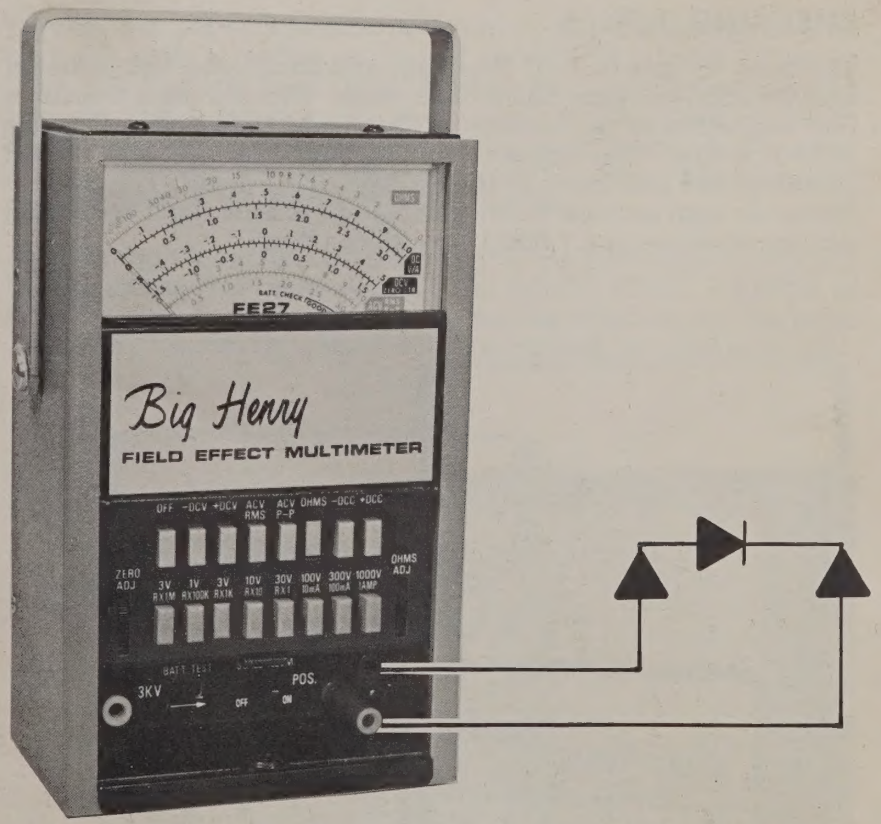

Fig. 10B Checking diodes, reverse direction

MEASURING DC CURRENT

Determine the polarity of the current to be measured with respect to the common or ground point in the equipment being measured. If the voltage producing the current is positive with respect to common, select the +DCC function, or if the voltage producing the current is negative with respect to common, select the -DCC function. Determine what current you expect to measure, and select a range that will give a reading as close to full scale as possible. If the current to be measured is unknown, start with the 1 AMP range, and work toward the 10mA range. Turn the power off to the equipment being measured, and open the circuit to be measured at the common or ground point. Plug the black test lead into the COMMON input jack, and the red test lead into the POS input jack. Connect the FE27

in series with the circuit being measured, with the black test lead clipped to the COMMON or ground point. Turn the power back on to the equipment being measured, and read the 0 to 1.0 DCV/A scale directly for the 1AMP range. For the 10mA range, read the 0 to 1.0 scale, and multiply by 10 to find the measured current in mA. For the 100mA range, read the 0 to 1.0 scale, and multiply by 100 to find the measured current in mA. Each small scale division on the 0 to 1.0 scale is equal to .02. Example: If the meter indication were 2 small scale divisions above the .7 mark, the scale indication would be .74. If the 10mA range were being used, the measured current would be .74 times 10mA or 7.4mA.

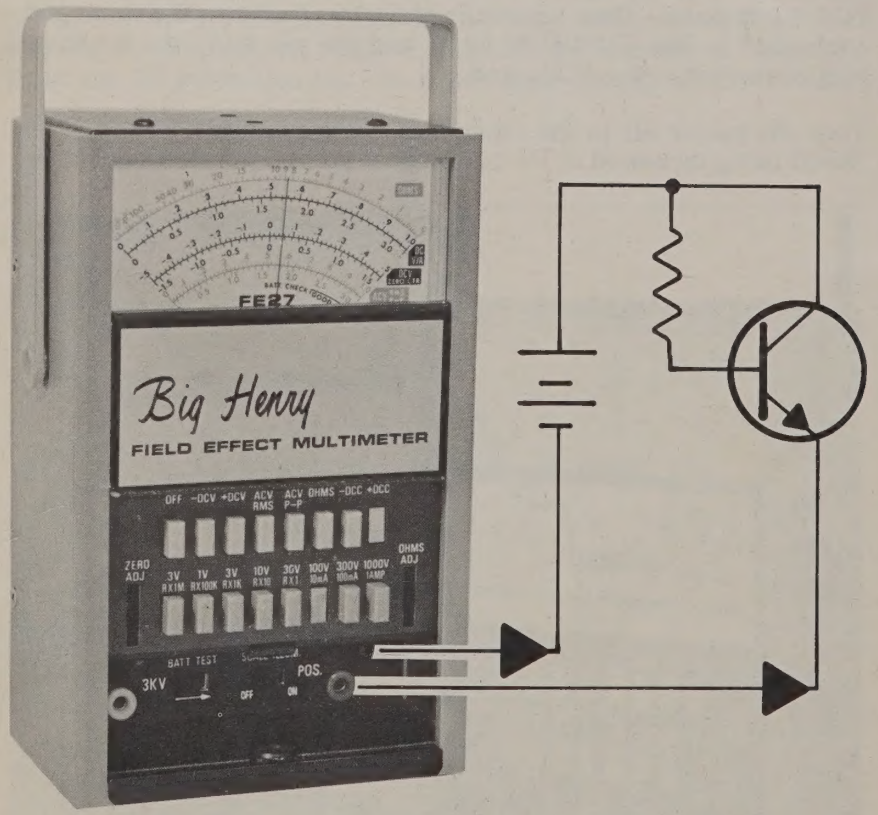

Fig.11 Measuring DC current less than 1 amp

MEASURING DC CURRENTS GREATER THAN 1 AMP WITH THE 39G82 SHUNT (OPTIONAL)

Currents between 1 amp and 3 amps DC or AC can be measured with the 39G82 shunt (optional) inserted into the COMMON and POS input jacks. The shunt resistor of .1 ohm is connected between the

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